Satellite Remote Sensing of Aerosols over Land from Geostationary and Polar Orbiting Satellites

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4PG8

Introduction

Past aerosol satellite research over land has been limited because the land surface is brighter and varies spatially and temporally more than that of the ocean. However, satellite remote sensing of aerosol information over land is a science in transition. It is transitioning from sensors not designed to be sensitive to aerosols (e.g., AVHRR, TOMS) to those with a specific objective to measure global aerosol information (e.g., MODIS, MISR). Nonetheless, both NOAA/AVHRR and GOES/Imager both have unique qualities not available in any new sensors. Namely:

Geostationary satellites provide temporal resolution unmatched by any polar-orbiting instrument.

The AVHRR instrument provides a climatology (1981-2000) unmatched by most satellite series.

These satellites can provide aerosol information over land, yet remain largely unused for such a purpose.

Purpose

To show the ability of the NOAA-series/AVHRR and GOES/Imager sensors to retrieve aerosol information over land.

Aerosol optical depth retrieval methods are described at right for both the GOES/Imager and NOAA-series/AVHRR and validated using surface sun photometer measurements in South America in 1995 and 1998 (from the aerosol robotic network, AERONET).

Data

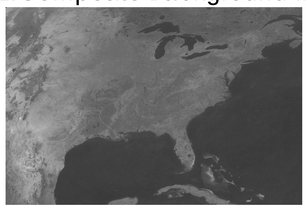
Satellite	GOES-8	NOAA seiries
Instrument	Imager	AVHRR
Data Source	CSU/CIRA	Satellite Active Archive
Temporal Coverage	15 min – 3 hour	24 hr.
Spatial Resolution	1 km x 1 km	110 km x 110 km
Spatial Coverage	1/6th of globe	Global

Note:
The background image of this poster is a false color image created from the Patmos dataset
(red = Ch. 1/Vis.; green = Ch. 2/NIR; blue = Ch. 3/IR)

Method

GOES

1.Composite Background Image

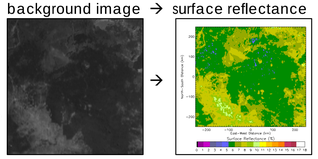


- Assume that aerosols increase the satellite-detected reflectance
- Use darkest pixels during a month to create a cloud-free, aerosol-free composite
- Example here is for the Eastern U.S.

2.Atmospheric Correction (in South America)

- Remove atmospheric effects ...
  - gaseous absorption
  - Rayleigh scattering
  - background aerosol extinction
- which provides surface reflectance

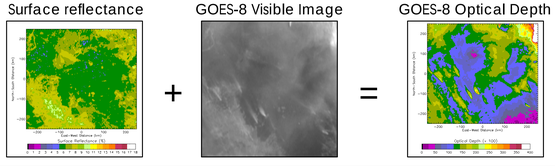
background image → surface reflectance



3.Retrieval of Aerosol Optical Depth

- assume aerosol optical properties
  - assume a smoke aerosol (concentrating on South America)

Surface reflectance + GOES-8 Visible Image = GOES-8 Optical Depth

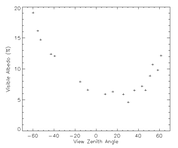


AVHRR

1.Composite Background Image

- Assume that aerosols brighten the surface
- Collect enough cloud-free observations such that the surface BRDF can be estimated
- *BUT* not too many that the surface albedo changes during the composite

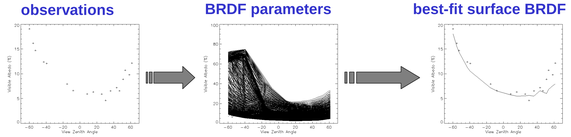
Example for Cuiaba, South America



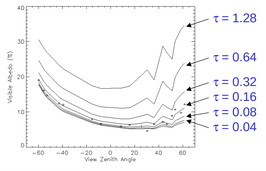
2.Retrieve Surface Bidirectional Reflectance

- Using Radiative Transfer Model, simulate all possible top of atmosphere reflectances possible from a typical surface BRDF
- Determine which BRDF parameters best match the observed angular variation

Cloud-free observations | Possible satellite observations simulated by varying the BRDF parameters | Cloud-free Observations with the best-fit surface BRDF

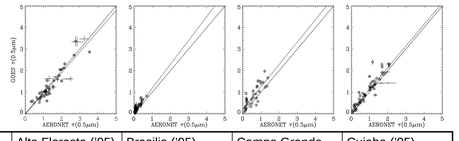


3.Retrieval of Aerosol Optical Depth

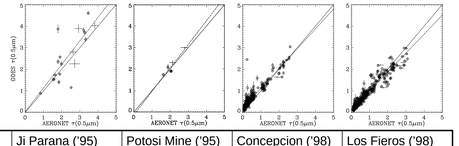


- Use:
  - retrieved surface BRDF
  - look up table with different optical depths (τ)
- Interpolate to the observed reflectance to retreive τ

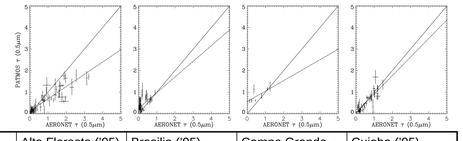
RESULTS



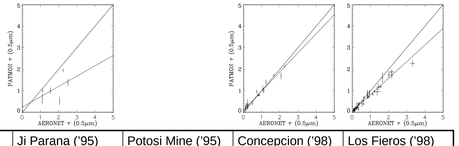
Site	Alta Floresta ('95)	Brasilia ('95)	Campo Grande ('95)	Cuiaba ('95)
Number	48	45	34	60
Correlation (r)	0.93	0.87	0.83	0.92
r.m.s.	0.29	0.13	0.35	0.29
Slope, Offset	0.96, -0.02	1.11, 0.08	1.04, 0.20	1.00, 0.13



Site	Ji Parana ('95)	Potosi Mine ('95)	Concepcion ('98)	Los Fieros ('98)
Number	19	6	377	646
Correlation (r)	0.78	0.93	0.94	0.97
r.m.s.	0.73	0.17	0.18	0.17
Slope, Offset	1.10, 0.04	1.10, -0.13	0.92, 0.20	0.88, 0.11



Site	Alta Floresta ('95)	Brasilia ('95)	Campo Grande ('95)	Cuiaba ('95)
Number	77	52	8	53
Correlation (r)	0.91	0.58	0.73	0.88
r.m.s.	0.43	0.29	0.35	0.19
Slope, Offset	0.57, 0.12	0.73, 0.25	0.48, 0.56	0.86, 0.05



Site	Ji Parana ('95)	Potosi Mine ('95)	Concepcion ('98)	Los Fieros ('98)
Number	6	0	24	58
Correlation (r)	0.55	n.a.	0.98	0.98
r.m.s.	0.83	n.a.	0.13	0.19
Slope, Offset	0.48, 0.24	n.a.	0.88, 0.11	0.81, 0.02

Conclusions

Both GOES and AVHRR show ability to retrieve aerosol optical depth over land.

- ☺ GOES (using a biomass burning aerosol model) retrieves optical depths with strong correlations and little bias.
- ☺ AVHRR (using a general continental aerosol model) retrieves aerosol optical properties with good correlation but more bias due to less absorption in the aerosol model

Future Work

AVHRR

- Include more information in the retrieval:
  - Spatial variations in aerosol optical properties (e.g, larger absorption in biomass burning areas)
  - TOMS Aerosol Index → Absorbing Aerosols
  - AVHRR Channel 2 → estimates the change in the vegetation
- Perform retrievals using the entire history of AVHRR (since 1981!!)

GOES

- Apply the retrieval to other areas
  - Ocean
  - Contiguous U.S.
- Calibrate and Apply the retrieval using other geostationary satellites
  - GOES-10
  - Meteosat
  - GMS

References

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- Patmos data was provided by the personnel at the NOAA satellite active archive (http://www.saa.noaa.gov/).